CLAIMS

1. A sensing apparatus for measuring the amount of a given gas in a gas mixture, said sensing apparatus utilizing the magnetic susceptibility properties of the given gas and comprising:

a magnetic core having a pair of elements spaced to form an air gap;

means for generating a magnetic field that traverses said air gap;

a deflectable membrane extending through said air gap;

means forming a chamber on each side of said membrane;

means for supplying the gas mixture to one of said chambers, the other of said chambers containing a reference gas; and

a mechanical-electrical conversion element mounted on said membrane and responsive to deflection of said membrane by the gas mixture and reference gas in said chambers when a magnetic field is present in the air gap to provide an indication of the amount of the given gas in the gas mixture.

2. The sensing apparatus according claim 1 wherein said mechanical-electrical conversion element comprises a piezoelectric element.

3. The sensing apparatus according claim 1 wherein said mechanical-electrical conversion element is formed as an annular member mounted on said membrane.

4. The sensing apparatus according to claim 2 wherein said piezoelectric element is mounted on said membrane so that the mechanical-electrical conversion occurring in said piezoelectric element occurs along a poling axis of said piezoelectric element.

5. The sensing apparatus according to claim 1 further including a

support for mounting said membrane to said chambers.

6. The sensing apparatus according to claim 1 further including means for providing a flow of the gas mixture through said one of said chambers.

7. The sensing apparatus according to claim 1 wherein said other of said chambers contains ambient air.

8. The sensing apparatus according to claim 6 wherein said other of said chambers contains ambient air.

9. The sensing apparatus according to claim 1 further including means to provide a flow of the reference gas through the other of said chambers.

10. The sensing apparatus according to claim 1 wherein said mechanical-electrical conversion element generates an electrical signal responsive to the deflection of said membrane and wherein a magnitude of said electrical signal provides an indication of the amount of the given gas in the gas mixture.

11. The sensing apparatus according to claim 1 wherein said mechanical-electrical conversion element vibrates mechanically responsive to the application of alternating electrical energization to said element, said element having an admittance, the admittance of said element at a given frequency of alternating electrical energization being alterable by deflection of the membrane, said sensing apparatus further comprising;

means for applying alternating electrical energization to said element; and

admittance measuring means coupled to said element for measuring the admittance exhibited by said element when alternating electrical energization is

applied to said element and said membrane is deflected by the gas mixture and reference gas in said chambers to provide an indication of the amount of the given gas in the gas mixture.

12. The sensing apparatus according to claim 11 wherein said admittance measuring means is further defined as measuring the admittance exhibited by said element at a resonant frequency alternating electrical energization.

13. The sensing apparatus according to claim 11 wherein said admittance measuring means is further defined as measuring the admittance exhibited by said element at a frequency other than the resonant frequency of alternating electrical energization.

14. The sensing apparatus according claim 11 wherein said admittance measuring means comprises:

means for applying alternating electrical energization having a desired voltage property which is constant in magnitude to said element;

means for measuring the current through said element; and

means for determining the admittance exhibited by said element from the voltage property and the measured current value.

15. The sensing apparatus according to claim 11 wherein said admittance measuring means comprises:

means for applying alternating electrical energization having a desired current property which is constant in magnitude to said element;

means for measuring the voltage across said element; and

means for determining the admittance exhibited by said element from the current property and the measured voltage.

16. The sensing apparatus according to claim 11 wherein said admittance measuring means comprises means for ascertaining phase shifts occurring in the alternating electrical energization as a result of its application to said element.

17. The sensing apparatus according to claim 1 further defined as a sensing apparatus for measuring the amount of a given gas in a gas mixture by utilizing the positive magnetic susceptibility, paramagnetic properties of the given gas.

18. The sensing apparatus according to claim 17 further defined as a sensing apparatus for measuring the amount of oxygen in a gas mixture.

19. The sensing apparatus according to claim 18 further defined as one for measuring the oxygen content of the breathing gases of a subject.

20. A method for measuring the amount of a given gas in a gas mixture utilizing the magnetic susceptibility properties of the given gas, said method comprising the steps of:

(a) forming an air gap across which a magnetic field can flow;

(b) placing a deflectable membrane through the air gap;

(c) forming a gas chamber on each side of the membrane;

(d) supplying the gas mixture to one of said chambers, the other of said chambers containing a reference gas;

(e) periodically providing a magnetic field across the air gap and through the chambers containing the gas mixture and reference gas, differing responses of the gas mixture and the reference gas to the magnetic field deflecting the membrane; and

(f) sensing the deflection of the membrane as a measurement of

the amount of the given gas in the gas mixture.

21. The method according to claim 20 further defined as providing a mechanical-electrical conversion element in operative association with the membrane for sensing the deflection of the membrane and for providing an indication of the amount of the given gas in the gas mixture.

22. The method according to claim 21 further defined as providing a piezoelectric element in operative association with the membrane for sensing the deflection of the membrane.

23. The method according to claim 22 further defined as sensing the deflection of the membrane by mechanical-electrical conversion occurring along a poling axis of the piezoelectric element.

24. The method according to claim 20 wherein the step of supplying the gas mixture to one of the chambers is further defined as flowing the gas mixture through the one of the chambers.

25. The method according to claim 20 wherein the other of the chambers contains ambient air.

26. The method according to claim 24 wherein the other of the chambers contains ambient air.

27. The method of claim 20 further defined as flowing reference gas through the other of the chambers.

28. The method according to claim 20 wherein step (e) is further

defined as providing the magnetic field at a switching frequency of up to 100 kHz.

29. The method according to claim 28 wherein step (e) is further defined as providing the magnetic field at a switching frequency of 0.1 to 5 kHz.

30. The method according to claim 21 wherein the mechanical-electrical conversion element generates an electrical signal responsive to the deflection of the membrane, the magnitude of which provides an indication of the amount of the given gas in the gas mixture.

31. The method according to claim 21 wherein the mechanical-electrical conversion element mechanically vibrates responsive to the application of alternating electrical energization to the element, the element having an admittance, the admittance of the element at a given frequency of alternating electrical energization being alterable by a mechanical loading of the element, said method further including the steps of:

(g) applying alternating electrical energization to the element at a selected frequency;

(h) measuring the admittance exhibited by the element when subjected to loading by the deflection of the membrane and energized by electrical energization of the selected frequency; and

(i) using the admittance properties of the mechanical-electrical conversion element as a measurement of the amount of the given gas in the gas mixture.

32. The method according to claim 31 wherein the mechanical-electrical conversion element has a resonance frequency at which the admittance of the element has a peak value and wherein step (g) is further defined as applying alternating electrical energization to the element at the resonance frequency.

33. The method according to claim 31 wherein the mechanical-electrical conversion element has a resonance frequency at which the admittance of the element has a peak value and wherein the step (g) is further defined as applying alternating electrical energization to the element at a frequency other than the resonance frequency.

34. The method according to claim 31 further including a step (j) of measuring the admittance exhibited by the element when the membrane is in an unloaded state when energized by the electrical energization of the selected frequency and wherein the method further includes the step (k) of measuring the difference between the admittances measured in step (h) and (j) as a measurement of the amount of the given gas in the gas mixture.

35. The method according to claim 31 wherein the step of measuring the admittance exhibited by the element further comprises the steps of:

applying alternating electrical energization having a desired voltage property which is constant in magnitude to the element;

measuring the current through the element; and

determining the admittance exhibited by the element from the voltage property and measured current value.

36. The method according to claim 31 wherein the step of measuring the admittance exhibited by the element further comprises the steps of:

applying alternating electrical energization having a desired current property which is constant in magnitude to the element;

measuring the voltage across the element; and

determining the admittance exhibited by the element from the current property and the measured voltage.

37. The method according to claim 31 wherein the step of measuring the admittance exhibited by the element is further defined as ascertaining phase shifts in the alternating electrical energization.

38. The method according to claim 20 further defined as a method for measuring the amount of a given gas in a gas mixture utilizing the positive magnetic susceptibility, paramagnetic properties of the give gas.

39. The method according to claim 20 further defined as a method for measuring the amount of oxygen in a gas mixture.

40. The method according to claim 39 further defined as a method for measuring the oxygen content of the breathing gases of a subject.